THE SYNAESTHESIA OF A BLIND SUBJECT

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The twofold purpose of this paper has been to report a very complicated case of synaesthesia and allied phenomena in the waking consciousness of a blind reagent and to review the literature on the subject of synaesthesia.*

Among the vast number of individual cases of synaesthesia which have been described in the literature there are to be found only a few reports of such secondary sensations in the blind. Fechner (41) discovered colored hearing in two subjects who had become blind. In 1892 Starr (127) described three cases of synaesthesis which he found among twelve pupils at the State School for the Blind in Iowa. Colors were here associated with tones, letters, digits and proper names. He tested these subjects over long intervals and found that their color associations were permanent. In 1893 Phillipe (109) found thirty cases of synaesthesia among one hundred fifty pupils in different institutions for the blind. These cases were all forms of colored hearing. He discovered that the colored associations varied according to the methods by which the pupils were trained or taught, particularly in literature and music. The synaesthesia also varied with different degrees of blindness. Only two of the thirty subjects could recall that their colored hearing began before they lost their sight. With only a few exceptions the remaining subjects were certain that their secondary sensations developed subsequent to their blindness. In cases where letters were colored, the point alphabet and not the Latin alphabet was usually the stimulus which evoked the colors. Where tones were colored, the brightness of the secondary sensations was determined largely by the pitch of the tones.

*In endeavoring to fulfill this latter purpose it was necessary to borrow much of the literature. The review is not complete but the writer believes that a majority of the more important articles have been covered in the review. He wishes to express his gratitude to Mr. M. H. Douglass, librarian at the University of Oregon, and to Mrs. Mabel E. McClain, whose assistance proved invaluable in obtaining literature which was unavailable here.

The frequency of twenty per cent which Phillipe found to prevail among the blind is somewhat higher than the frequency of synaesthesis among the seeing, for among the latter, the average estimate has been fifteen per cent. Phillipe suggested that this greater frequency of colored associations among the blind than among sighted people might be due to the fact that the blind, who have formerly seen and have recognized colors, make constant efforts to retain their imagery of these colors. Since visual sensations have been eliminated, they are obliged to associate colors with experiences from sense fields other than the visual. It is interesting to note that Phillipe failed to discover any synaesthesis among pupils who were deaf. Although he did not carry this part of his investigation far enough for conclusive results, the lack of synaesthesis among the deaf, if true, would be consistent with the fact that most of the forms of color associations of this kind are of auditory origin. Flournoy (44) made a contemporary investigation of twenty-five blind subjects and found one case of colored hearing, six who had number or other forms, and one who had a marked case of "personification." Coleman (26) observed a case of colored hearing in a subject who had lost his sight at the age of five years, after the synaesthesis had already developed. After blindness appeared there were no marked changes in the colors.

One of the earliest obtainable records of synaesthesis was made by Hoffman in 1786 (63). In this record was described the case of a Swiss magistrate and painter who had numerous varieties of colored hearing. No attempt to thoroughly investigate the case appears to have been made. Another early mention of colored hearing is to be found in Goethe's "Theory of Colors" (53), published in 1810. In 1812 Sachs (120) described a very interesting case of an Albino whose synaesthesis included colored vowels, consonants, musical tones, digits, cities, days of the week, dates, epochs in history and certain abstract terms which had to do with phases of human life. Sachs attempted to treat the problem systematically. In his classification of different forms of synaesthesis into acoustic, optical and psychological, according to their origin, we find a very early and noteworthy recognition of both a physiological and a psychological problem in the phenomenon of secondary sensation.

In 1843 Gautier (52) reviewed his own case of colored hearing, which he found could be stimulated artificially by means of

hasheesh. The problem was attacked in 1848 by the oculist, Cornaz (31), who thought that in colored hearing he had found a form of Daltonism similar to color-blindness and subject to the same laws of heredity. Accordingly, he attributed this form of synaesthesis to a hyperaesthesia of vision. In 1859 Ehlert (37) described his own associations of color with music. The next year, 1860, Marcé (89) attributed synaesthesis to an optical defect, as Cornaz had done. In the same year Vauthier (140) described his own case, a very peculiar feature of which consisted of the act of associating severe tooth-aches with tones of a certain pitch and quality.

In 1863 Perroud (107) attacked the current view that colored hearing was pathological, and substituted the view that the laws of association would adequately explain the origin of such phenomena. This conclusion he derived largely from the details of his own case. The pathological view was again attacked in 1864 by Chabalier (23) on the ground that the view could not be substantiated, and for the further reason that he believed synaesthesis to be due to a confusion of ideas or to a psychic perversion. How else could be explained the fact that in his own case letters were colored so vividly that their meanings entered consciousness only after the colors had appeared? Or how was it, otherwise, that he often forgot proper names but never forgot their corresponding colors? For Chabalier, therefore, colored hearing was nothing but an illusion!

In 1871, Rause (115) reported a case of synaesthesis which was apparently associated in a most remarkable way with a gunshot wound in the lungs. The subject in question had been struck by the bullet in the spina scapulae and had sustained a second exterior wound in the first intercostal space, where the bullet had found its exit. When a weak solution of lactic acid was poured into the anterior wound the subject could taste the liquid. This accidental discovery lead to several very careful tests in which every precaution was taken in order to eliminate the influence of smell and of suggestion. Under these latter conditions, even when the subject had no warning of the stimulus, he tasted weak solutions which were poured into the anterior wound. In fact the patient was able to judge the strength of the solution fairly accurately by means of the intensity of the concomitant taste. Similar tests in the posterior wound failed to arouse any taste sensations.

In 1873 J. A. Nussbaumer (103) reviewed his own case of synaesthesis and also his brother's case, both of which were very complicated and both of which began at the age of four or five years. At this early period in their lives these two brothers argued and fought between themselves as to the colors which they thought belonged to the tones of certain musical instruments. Later, one of the brothers noticed that these same color associations accompanied auditory images in his dreams. Certain peculiarities of the photisms were noticed by the other brother, among which was the localization of his colored photisms either against the forehead or immediately in front of it, instead of in the direction of the sound, as is more frequently the case. He also noticed that at times he could listen to lengthy concerts without the appearance of any colors, while isolated tones were always colored. Nussbaumer attempted to throw light upon the origin of colored hearing by observing the possible effect on the photisms of passing weak electric currents through different portions of the brain. Only negative results were obtained beyond the fact that the current caused faint flashes of color to appear when it was passed through the forehead between the temples! Although this investigation offered no solution to the problem, it stimulated a considerable amount of literature on synaesthesia, first, perhaps, because of its thoroughness as far as it went and secondly, for the reason that it gave an opportunity for further theoretical speculation. Here the origin of the phenomenon could be traced beyond a doubt to early childhood and here, also, the colored hearing undoubtedly depended upon auditory stimuli.

In 1876, Nuel (102) tried to explain the Nussbaumer cases from a physiological point of view by attributing the phenomena to a deterring of afferent nerve currents from their usual course to areas of the brain adjacent to their normal terminus. After these currents reached the adjacent area they aroused some form of molecular disturbance, eventually giving rise to false sensations. In the same year Fechner (40) published the results of an investigation of about three hundred individuals who possessed some form of synaesthesis. The chief purpose of this study was to discover a possible objective basis for the secondary sensations. He failed in this attempt and continued his study of the problem by resorting to statistics and the questionnaire method. Here again he found too many exceptions to every rule, and his attempt to find the origin of synaesthesis brought negative results.

Pouchet and Taurrieux attempted to explain colored hearing physiologically in 1878 (113), and introduced the view that colored hearing was a result of abnormal crossings and unitings of afferent fibers. The writers upheld their conception by a reference to the Helmholtz theory that each fiber of an afferent nerve determined a sensation of specific quality. Pedrono (106) attacked this view on the ground that too many fibers would have to cross one another in order to account for the many individual colors which accompanied numerous tones of varying pitch and quality. In 1881 Bleuler and Lehmann (16) devoted a monograph to a detailed study of synaesthesis in its various known forms and described a large number of new cases. Among the latter was one in which acute angles were always a very light grey; obtuse angles were the opposite; wavy lines were a very dark shade of green; circles were bright yellow; triangles were silver; and rectangles were light grey. Here we find a case of synaesthesis which was evidently dependent upon optical stimuli. In the same monograph were described instances of colored tastes, colored odors, and colored tactual sensations. By resorting to a statistical study of large numbers of cases, the authors tried to find a clue to the origin of synaesthesis, but they were no more successful than Fechner had been. The following are their more important conclusions: (1) The colors of words and letters are not always dependent upon the sound but often upon their meaning; (2) bright photisms are invariably associated with tones of high pitch, with intense pain, or with punctiform or sharp pressure sensations; (3) dark photisms are associated with tones of low pitch, with blunt pain and pressure sensations; (4) according to their frequency of occurrence the reds, yellows and browns come first, followed in order by blue, violet and green; (5) approximately twelve per cent of normal individuals have some form of synaesthesia and the phenomenon is rarely found among the insane; (6) many cases of synaesthesia are probably inherited; (7) these facts lead to an association theory.

In 1881 Kaiser (72) supported the association view of Bleuler and Lehman, and supplemented it with the suggestion that many subjects make a voluntary effort to improve their memory while they are young by associating colors with sounds, letters, words and the like. In the same article Kaiser reported a peculiar case of synaesthesis in which German words were green, English words were brown, French words were a very dark brown and Greek

words were yellow. In 1882 Pedrono (106) noticed that the colors which were associated with musical sounds were localized very differently by different individuals. Colors might be localized above the person who was singing; they might be suspended in mid-air above the sounding instrument; or they might be localized in space directly in front of the subject. Pedrono also observed that when the object making the sound was not visible to the subject or when the subject closed his eyes, the colors were localized in the direction of the sound. When the subject was placed in a dark room and the sound was carried to him by means of rubber tubes, the colors were seen in their usual vividness and in their usual localization. In his own case of colored hearing not only did the objective sounds arouse colors, but images of those sounds as well.

In 1883 Galton collected a considerable amount of data on various forms of synaesthesis (49) from which he concluded that vowels were more likely to be colored than consonants, and that most types of synaesthesis were inherited. He was perhaps the first to point out that number forms and synaesthesis frequently go hand in hand, that is, many number forms possess permanent colors as well as permanent shapes and outlines.

In 1883 and later in 1888 Baratoux (5, 6, 7) advanced the view that colored hearing might depend upon an anastomosis of brain centers or of fibers leading to the brain from the organs of the senses associated in synaesthetic fashion. He believed that this anastomosis was to be found to a certain extent in all individuals and that all persons, therefore, had some form or degree of synaesthesis, no matter how slight. In 1884 Lussana (86) ventured the further suggestion that those brain centers lying adjacent to one another might be so connected by nerve paths as to render reciprocal aid in such physiological activities as underly the process of perceiving.

A series of investigations was begun in 1885 by Holden (64) and continued at intervals until 1906 (65, 66, 67, 68) with his daughter as the subject. Her synaesthesia was tested at the ages of seven, eight, ten, fourteen, seventeen and twenty-one. During this time the only changes that had occurred in the colors were the shift of cream to white as the associate of the digit 8, and the shift of brown to black in the color associated with 10. Twenty-four years after the first tests had been made, colored letters, digits

and days of the week had undergone only very minor changes in their brightness qualities.

In 1885 and 1886 Lauret (78) published data on several individual cases, including the interesting variety of colored hearing in which the letter "A" was a black oval with a perpendicular axis; "E" was a square of muddy straw-yellow, and so on. In 1885 Rochas (117) described a form of colored hearing in which the colors were not externalized, but were localized on the subject's brain. Words and letters of different languages were colored uniformly according to the language. Low tones were very dark or nearly black and as the tones varied upward in pitch the associated colors passed through the hues of the spectrum in regular order, beginning with red.

Feré (42) rejected the view of anastomosis or tangling of fibers and substituted the view that the nervous system has a certain "tone" which renders it amenable to synaesthetic results either with normal stimuli such as sounds, letters, words and the like, or with abnormal stimuli, such a drugs. In 1887 (128) Steinbrügge suggested that synaesthesis began in early childhood as a direct but double perception, or as a primary perception accompanied by a sub-perception. The sub-perception could not be due to association for the reason that the colors appeared too suddenly upon the perception of the sound or letter, leaving no time for the forming of associations. He resorted, therefore, to the physiological conception of anastomosis of fibers and to the resulting deterring of excitations from their usual channel to areas of the brain adjacent to the normal terminus of such excitations. The author seemed to favor the association theory, however, in explaining certain forms of permanence in colored hearing.

In 1888 Urbantschitsch (136) found that catarrh of the middle ear or a defect in the outer ear might, in certain instances, influence the patient's capacity to see and that stimulation of the eye or of the ear might facilitate the functioning of the other organ. These facts lead the investigator to conclude that he had found another variety of synaesthesis which appeared under entirely new conditions. Further experiments showed that this mutual influence between the functioning of the eye and the ear could be studied under experimental conditions. Among certain subjects he found that the perception of a tuning fork might be changed both in intensity and quality by light stimuli when the latter were presented simultaneously with the sound. It is a

question, however, if attention did not have something to do with this result. In one subject, spots and streaks of grey appeared on a sheet of paper when a tuning fork was sounded. Another subject found the paper to take on a reddish tint under the same conditions. Still other subjects appeared to see other colors on the paper. Such results were not obtained with observers who did not possess colored hearing. These results lead Urbantschitsch to conclude that the peculiar response which he obtained in one sense field when another sense field was being stimulated was due to a peculiar form of reflex. This view he expanded, theoretically, to cover all forms of synaesthesis. More recent studies of the conditioned reflex made it seem plausible that the phenomenon which Urbantschitsch was dealing with might have been a form of the conditioned reflex.

In 1890 Mendoza (95) reviewed two interesting cases of a brother and sister who had colors for tones, for musical compositions and for composers' names. For one of the subjects, Hadyn's music was green, Mozart's was blue, Chopin's was red and Wagner's was cloudy grey. Auditory imagery of these compositions aroused the appropriate colors as well as the actual music itself.

In the same year Raymond (116) found clinical evidence, he thought, of a very close anatomical and functional relation between those brain centers which functioned in synaesthesia. There seemed to be unusual nerve connections which linked one of these areas with the other. In the same year, also, Spencer (125) reported a case of synaesthesia in which vowels were colored and in which words were colored according to the vowels which they contained. In those words which had more than one vowel, the accented syllable or a dominant vowel determined the color. In 1891 Jordan (70) described his own color associations which bore many resemblances to the case just previously mentioned. In addition, there seemed, in Jordan's case, to be a peculiar inconsistency in the color associations, for the word *red* was green and the word *blue* a different shade of green. The letters or words themselves did not assume the colors but were visualized on a colored background. Jordan accepted an association theory of colored hearing for the reasons: (1) in his case and in many others, the vowel "I" was black or very dark, due perhaps to the fact that "I" is a black line; (2) the vowel "O" was white or very light, due to the fact that in this letter there was a white space surrounded by the outline of the letter; (3) in many instances

it happened that the color of a favorite letter was a favorite color. The difficulty with this method of explaining color associations is to be found in the impossibility of applying it to more than a few isolated cases. Jordan's own observations verified those made by Spencer in that the color and the shade of the letters depended in part upon their form, in part upon their sound and in part upon their meaning.

A very valuable and extensive review of the literature on synaesthesia was published in 1891 by Mendoza (96). In 1889, 1892 and 1893 Grüber (55) reported several remarkable cases of synaesthesia, some of which proved of great advantage to the subjects. In one instance so faithful were the associations of colors with digits that the subject was able to perform mathematical operations by means of colors. In this respect this case resembles the one which will be described later by the present writer. In another instance a singer was able to judge the accuracy of pitch by means of the fine differences in shades and tints of his colored tones. Another subject was able in the same way to change the quality of his voice to a very minute degree. Grüber employed the method of measuring projected photisms with a millimeter scale in order to determine the constancy of the colors over long periods of time. His subject in this experiment was a Roumanian who associated colors with digits and diphthongs. The names of the digits were presented to him in the Roumanian language for the reason that his colored hearing was acoustic in origin. The subject was asked to project his photisms upon a white cardboard. The photisms themselves were either circular or oval in shape. The cardboard was surrounded by a colored background and the size of the white interior was varied until the limits of the projected photism corresponded exactly with the limits of the white cardboard. For example, the digit "2" was associated with a bright yellow circle. The central cardboard was made in the form of a disc the same shape as the photism. When the subject was asked to project his yellow photism upon the white disc, and the disc was surrounded by a red background, if the disc was too large for the photism there appeared around the edge of the photism, between it and the red background, a band of white, where the disc extended beyond the limits of the photism. If the disc were too small, there appeared on the red background just around the disc a band of orange where the photism extended beyond the limits of the disc and onto the red background. When

both the orange and the white bands failed to appear the experimenter knew that the size of the white disc and the size of the photism exactly corresponded. Many of the photisms were oval rather than circular. When different digits were presented to the subject in serial order and according to their value, the vertical diameter of the oval increased with the addition of every syllable in the name of the number. The horizontal diameter of the photisms increased with the addition of every cipher. The diameter of the photisms of the units class was twenty-one millimeters; the photisms of the tens class were twenty-three millimeters in diameter; the hundreds class were twenty-six millimeters; the thousands class were thirty millimeters; the hundreds-thousands were forty-one millimeters; the millions class were forty-eight and so on. If each of these diameters be substracted from the one previous the differences will read two, three, four, five, six, seven and so on. This remarkable relationship held between the differences in the diameters of photisms of numbers as high as the billions class. A further remarkable feature of this subject's photisms was the fact that one dimension grew vertically and depended upon the phonetic element of the name of the digit; the other dimension grew horizontally and depended upon the arithmetical element or class to which the number belonged. Both diameters increased in the same proportion.

In 1892 Schooling (121 a) suggested the creation of a new art —color music. He evidently obtained his idea from reading Grüber's description of synaesthesia. The instrument for this new art was intended to be an electrically operated "color-organ," provided with a set of vacuum tubes which could be illuminated, giving various successions and combinations of colored lights, controlled from an ordinary key-board. How successful the experiment was we are not told.

In 1893 Flournoy (44) published the results of an extended questionnaire. Two thousand six hundred circulars were sent out six hundred ninty-four of which were answered and returned, giving a total of three hundred seventy-one cases of synaesthesia. From a study of these cases the author concluded that the principle of association offered a better explanation of most forms of synaesthesis, rather than a physiological theory. In many instances the colors were obviously due to associations which had been formed between the tone, digit or letter and the color equivalent and also between an affective or emotional process and the color.

The affective process was often common to the tone, digit or letter and the color of the photism. In this way favorite colors were apt to become associated with favorite tones, letters and the like and unpleasant colors might be associated with unpleasant tones or letters. Flournoy classified the different kinds of synaesthesis, according to their mode of origin, into: (1) habitual associations which were the result of simultaneous perceptions of color and sound; (2) privileged associations, or those whose practical value to the subject had lead to their frequent repetition and subsequent fixity; (3) feeling associations, which were due to the fact that letters and tones aroused the same affective processes as did the colors. In the same monograph this author described the colored hearing of a painter who frequently secluded himself with his violin in order to find colors for his paintings in the visual equivalents of his music.

The association theory received another adherent in 1893 in Stevens (130) who attempted to show how color equivalents might be formed in an indirect way. For example, in his case, the letter "d" was associated with "dog;" a certain black dog represented "dog" in general to him, hence the letter "d" came to be associated with black and always aroused that color. The letter "v" is the first letter in vulture, a brown bird, hence "v" came to be associated with the color, brown. But "v" is the first letter in violet. Why was it that "v" itself did not come to be associated with that color instead of brown?

Krohn published a history of the various theories of synaesthesia in 1893 and also described certain prominent cases in the literature together with one of his own observations (73). The subject on whom he made his observations was a young musician whose colored words, letters and digits were partly of acoustic and partly of associative origin. The colors depended both upon the sound and upon the meaning of the letters and digits. In certain instances the shape of the letters seemed to determine the color. Words pronounced alike but spelled differently had different colors. The colors of music were determined by the key in which the music was written. Curved letters were usually tan and straight lines were often red. From these facts and from details of other cases, Krohn concluded that certain forms of synaesthesis were undoubtedly due to the principle of association. On the other hand he conceded that the majority of cases could

only be explained by a physiological irradiation between cortical centers.

A new method of attack upon the problem was made by Binet and Phillipe in 1892 (13) who employed the reaction method to determine the association time between letters, digits and the like and their corresponding colors. In the same year Beaunis and Binet (8) performed similar experiments and in the year following Binet and Phillipe (11, 110) published further results from the same type of experimentation, this time individually. In these series of experiments, which were made in the same laboratory at different times and on five different subjects, one method consisted of exposing to the subject a series of letters or digits to each of which the subject responded with the appropriate color. This was checked up by asking the reagent to respond with the first letter or digit which appeared in consciousness after the stimulus was perceived. The time required by the subject to finish the entire series was then divided by the number of letters or digits in the series and an approximate reaction time for each letter or digit was thus obtained. Another method consisted in presenting to the subject certain letters or digits in isolated fashion to each of which he responded with the appropriate color or with an associated letter or digit. The reaction time was obtained for each separate response and the average taken. In view of determining the subject's reaction type there were tried simple sensory and motor reactions, simple association reactions and choice reactions. No far-reaching results were obtained from these investigations. The time required for the appropriate color to appear after the letter or digit had been exposed was ascertained by subtracting the average reaction time in the letter-color and digit-color series from the reaction time of the letter-letter or digit-digit series. This gave a result of approximately sixty sigma.

In 1893 Thorp (133) reported his own colored hearing which proved to be of so great an annoyance to him in his music that he had to give up his musical education. In 1892 and again in 1893 Miss Calkins (20, 21) published the results of a questionnaire study of synaesthesis. In the first investigation five-hundred forty-three persons were questioned, among whom thirty-four had synaesthesis, including thirty-three cases of colored hearing, nineteen of colored names, thirteen of colored days of the week, seventeen of colored letters and three of colored alphabets. Galton's assertion that vowels are more frequently colored than consonants

was not borne out. Word coloring could not be reduced to any formulae because at times the word took on the color of the initial letter; at times the color of an accented letter; or at times the color of the word was a mixture of the colors of the component letters. There seemed to be an indication that *i* and *o* were colored light and dark respectively, in many individual cases. In the second article results were published from a questionnaire which reached two hundred three subjects. This time there was found a far greater percentage of synaesthesis than was found in the former study. The author attributed this to improved methods of questioning and to a better preparation of her subjects for such questions as were asked them. Over one hundred different varieties of colored letters, digits, names, days of the week, noises, tones, composers and the like were found, and most of these associations were apparently fortuitous save for the colors of *i* and *o*. Again these latter were often dark and light. Miss Calkins sought to answer or throw more light upon the problems: (1) Do the colors of letters or of digits depend upon the sound or upon the meaning of the latter? (2) Do these associations depend upon a feeling tone common to the color and to the digit or letter? But no such uniformities among different individuals were found as would enable the investigator to form a general conclusion regarding either of these questions. The negative results might have been due to the fact that the subjects themselves were often unable to answer the questions upon which the results depended.

Out of the forty-five subjects who had colored words, twenty-seven had colored imagery of these words; in certain instances the words or letters themselves were colored but quite as often their colors appeared as backgrounds upon which the words or letters were superimposed, visually. In still other instances the words and letters were not visualized at all. There seemed to be no constant relation between the colors of words and the colors of component letters. The majority of cases of synaesthesis showed no tendency toward inheritance. It is not surprising, therefore, in the face of such a dirth of uniformities that generalizations were impossible. Among certain individual cases abstract ideas and personal traits were associated with colors. One case of "personification" was found in which certain letters had the following characteristics: *K* was a young woman, the friend of *L* and the daughter of *M; O* was a young nephew of *M; Q* was an eccentric middle-aged man; *R* was a clever admirer of *S* and so on.

Occasionally the subject changed the traits of these letters in a fanciful effort to keep harmony in her large alphabetical family. As a result of these two studies, Miss Calkins concluded that the following percentages were representative of the distribution of synaesthesis among individuals: Synaesthesis proper, fifteen per cent; number forms, thirty per cent and both together in the same individual, eight per cent.

A third investigation was made in 1894 (22) giving the results of two hundred cases which were studied over the interval of a year. From this number forty-three cases of colored hearing were found, together with seventy-two of colored words, sixty-three of colored music, fourteen of colored digits and numerals, six of colored tastes, six of colored pressure or temperature, one of colored pain and one of colored odors. Again the author collected evidence against Galton's statement that vowels were more often colored than were consonants. In this and her preceding articles she presented numerous tables indicating the relative number of cases in which synaesthesia was thought by the subject to depend upon (1) early formed associations, (2) upon a common emotional tone. The tables also included the number of cases in which the color associations proved to be an advantage or a disadvantage to the subject and the number of instances in which the colors were clearly or only dimly localized. These tables indicated that the association and emotional theories of the origin of synaesthesis held in a little over one-half of the total number of cases. They also indicated that the colors were usually distinctly localized and that the associations were generally of no particular value to the subject. Thus the method of arranging a large quantity of statistics in tabular form failed to produce any real positive results. The third article is valuable, however, for the reason that there is included a very elaborate questionnaire which was used in the two later investigations.

In 1896 Lay (80) reported three cases of synaesthesis in three sisters, aged nine, ten and twelve. No evidence was found that the color associations were inherited. All three sisters had colored alphabets, colored digits from one to twenty, colored proper names, days of the week, months of the year and certain other names. The associations dated back as far as the subjects could remember. In the same year Epstein (38) suggested a new variation of a physiological interpretation of synaesthesis. Auditory excitations generally follow their regular course to the auditory center

of the brain but in certain instances some of these excitations might be deflected at the corpora quadrigemina where the proximity of visual and auditory ganglia is very close. From here the auditory excitations might pass over visual paths to the visual area of the brain.

A valuable discussion of synaesthesis was published by Hennig in 1896. In this paper (59) he classified secondary sensations as physiological and as psychological, according to their origin. The first group depended upon peculiar nerve connections and the second depended upon the formation of peculiar associations. That certain forms of synaesthesis were undoubtedly psychological in origin was borne out by the striking example in which a certain subject associated clarinet tones with the color, blue. At one time this subject was listening to a clarinet solo, while standing out of doors. As he was looking upward toward the sky, he became absorbed in the tones from the instrument, momentarily noticing at the same time that the blue of the sky was unusually rich and clear. From that time on clarinet tones aroused this same shade of blue. Of chief interest to this author was the practical value of many forms of colored hearing and for that reason a considerable portion of the article was devoted to this phase of the topic. He observed that poor spellers, who were at the same time synaesthetic, were occasionally helped by the colors which always accompanied different letters. Painters and musicians had recourse at times to their color associations in painting and in composing. Mathematicians sometimes used their color associations to good advantage in solving mathematical problems. On the other hand he found so few instances in which the secondary sensations were a positive disadvantage that he believed them to be an agent of superior mental endowment. He took the attitude that the associations should be cultivated by all individuals.

In 1897 Flournoy (46) described an elaborate and striking case of "personification" in a young man of nineteen. Names of the days of the week were dramatized as follows: Monday and Tuesday were a sad young man who held a fore-finger over one eye. This figure designated dark weather. Wednesday was a young man in the act of stealing an object behind him, bending over and extending his arms backward, between his legs. This figure also indicated dark weather. Thursday was a man in the act of turning a knob in the kitchen door on his way to the room

beyond. Friday was a man in the act of selling from a wagon the object which was stolen by "Wednesday." Saturday was a man in the act of falling against a door for the sake of amusement. This figure meant clear weather. All the figures were lacking in color but were definite in outline and especially in facial expression. Certain words were colored and others were dramatized. "Autumn" was the same man who represented Monday and Tuesday; "Battle" was a large woman seated at a little bench near a table, laughing. "Shark" was a large horse which stood near a load of hay. Whenever the subject saw or heard the word "shark" this imagery appeared in consciousness before the meaning of the word or before there appeared in consciousness the idea, fish. The tendency to form these associations reached its maximum when the subject was between eight and ten years of age and rapidly declined after the age of twelve. In his earlier life these personifications had been so marked as to dominate consciousness and to require voluntary effort to eliminate them. The subject had always possessed an unusually vivid imagination and he constantly anticipated the subject matter of a conversation or of a book, by means of vivid visual imagery. The remarkable ease and rapidity with which images were linked with words either voluntarily or involuntarily, relevantly or irrelevantly, seemed to be a peculiar trait of the subject's mental make-up. This trait lent itself readily to the development of personifications. It is possible that here we have a case which might be taken as evidence of Ferè's view that synaesthesis depended upon a certain "tone" of the nervous system. In this instance the "tone" might consist of an unusual elasticity of the nervous system, or a like condition.

In the same year Grafé (54) suggested that by making use of colored hearing and like phenomena, the blind could be made to see and the deaf to hear. But the suggestion has never been carried out! In 1898 Clavière (25) made an effort to standardize the various terms which were used to designate different forms of synaesthesis. He also reported instances of colored hearing in poetry and prose writings. His review of the subject of synaesthesis covered nearly all the current theories. In 1900 Whipple (144) made a series of tests upon two subjects who had highly complicated forms of synaesthesis. By carefully controlled methods, supplemented by introspections he was able to obtain far more accurate data from his subjects than had hitherto been

obtained from other subjects with the questionnaire method. In order to make a complete survey of his subjects' associations he employed tuning forks, the simpler musical instruments and the pipe organ. One subject had colored odors and tastes and cutaneous audition all of which were studied as far as possible with the help of standard laboratory apparatus. The sound images or phonisms which accompanied pain, pressure and temperature sensations are without parallel in the literature. The other subject endowed letters and digits with human traits without the use of visual imagery. Whipple found that fatigue hindered the appearance of the colors, a find which was contrary to Flournoy's belief. Also, contrary to Bleuler's generalizations, Whipple found that the uniformities which were supposed to exist in associating light colors with high tones and dark colors with low tones were subject to serious question. His own observations, however, on only two subjects did not enable him to throw any light upon the origin of synaesthesia. In 1901 Laignel-Lavistine (74) found cases of synaesthesia in ten out of eleven individuals in a certain family of three generations.

In 1903 Urbantschitsch (137) investigated the synaesthesis of a limited number of subjects and here he compared the relative strengths of the associations between colors and tones when each ear was stimulated separately. He found the striking result that such bonds of association between colors and tones varied in strength with the stimulation of different ears in the same subject. He further made an attempt to find if the colors of tonal combinations followed the laws of color mixture. He sounded together two tuning forks, or two single tones whose colors were complementary on the one hand or antagonistic on the other. In a few isolated instances complementary colors, under these conditions, seemed to blend or to neutralize one another. The usual result, however, was the dominance of the color of only one of the tones. In the same year Dresslar (36) published a detailed study of an individual whom he tested in 1895 and again in 1903. He obtained the usual result, namely, that in the meantime practically no changes had occurred in the color associations. He also found, in agreement with other investigators, that the colors of words or of numerals were determined in several ways: (1) by the colors of initial letters; (2) by the colors of an accented syllable; (3) by the color of a repeated letter or digit; (4) by a digit or letter whose color was unusually vivid or striking. He

discovered, as did Whipple, that fatigue made the photisms less vivid and clear.

Several cases of synaesthesia seem to originate so abruptly in the early life of the subject as to appear to result from shock or from some highly emotional experience. Occasionally such forms of synaesthesis are so vivid and persistent as to resemble hallucinations. Lemaitre reported an instance of this sort in 1904 (82) in a young child whose color associations were so vivid as to occupy the focus of attention whenever they appeared in consciousness, even blinding him temporarily to the extent that he was unable to perceive visual stimuli of ordinary intensity or brightness. This partial blindness lasted as long as the photisms remained in consciousness. In the same paper, Lemaitre reported a case of colored hearing in a child strikingly similar to that of the mother. In 1905 Rossigneux (119) attempted to show how certain instances of colored hearing, in poetry, followed definite laws. These laws related to the poetic and sound value of consonants and vowels. His conclusions, however, were based on insufficient data. In the same year, Smith (122) reported cases of synaesthesia in a father and his five children.

In 1907 Pierce (111) reported a hitherto undescribed variety of synaesthesia, gustatory audition. The subject was slightly deaf and so anosmic as not to be able to detect the odor of burning coffee. Tastes were recognized not only by means of the elementary taste qualities themselves but by the "feel" of the texture and of the astringency of different foods. Words were associated with these taste and pressure complexes. The following are typical illustrations: Alfred—cornbread in milk; Arthur—small particles of delicate lamb; Emma—pie crust; marry—raisins; hope—celery; loud—boiled potatoes; story—stewed cranberries; who—thick, salty cream. Many of these tastes would appear when the words occurred in conversation or in a lecture to which the subject was listening. The manner in which these words were pronounced influenced the associated tastes thus indicating that the synaesthesis was acoustic in origin. "Light" for example when rapidly pronounced aroused the taste of the soft, juicy lobe of grapes, but if pronounced slowly this same word aroused the taste of chicken gravy. Words had different tastes when pronounced by different individuals. This seemed to indicate that the quality of the sound determined the taste imagery. Her taste associations were so many in number that all of them could

not be recalled voluntarily but when the appropriate stimulus was pronounced to her the associated taste never failed to appear. These associations could not be reversed unless the connection between the two sense fields had been remembered and had just been recalled. In testing for the taste equivalents of different words it was the habit of the subject to pronounce the words herself in order to "reinforce the auditory excitation." When in doubt as to the quality of the taste she applied pressure to her cheeks with her fingers. Taste associations were revived most readily when the subject was in a state of natural hunger, a fact which seems to point to a physiological basis. If a lecture or a conversation to which she was listening happened to be just prior to a meal the taste imagery was exceedingly tantalizing. Nonsense syllables, which had been unthought of by the subject before the experiment began, served to evoke taste qualities the first time they were pronounced to her. "Sut" gave mutton fat; "yoz" gave the taste of the white of an egg beaten stiff; "hes" aroused the taste of small particles of mince meat. Undoubtedly association played a considerable role in these latter tests. "Sut" might suggest "suet," a form of fat; "yoz" might suggest the sound of beating up an egg; "hes" sounds something like "hash" etc. Many of the subject's taste images were aroused in the absence of any awareness of the stimulus. For example at one time she was working in a library and while busily engaged in her work she suddenly tasted roast beef. Casting about for a cause, she heard men's voices in an adjacent alcove. The following facts seem to support the conclusion that this case depended upon physiological factors: (1) the associations were constant; (2) the subject was slightly deaf and slightly anosmic; (3) the taste qualities depended upon the rapidity and the quality of the auditory stimuli; (4) many of the taste qualities resisted introspective analysis; (5) the gustatory imagery was clearly localized in the reagent's mouth and was so vivid as to approximate actual taste sensations. In 1911, 1912 and 1913 the author of this study reviewed the current literature on synaesthesia (112).

Colored hearing in a color-blind subject was reported by Evans in 1907 (39). The subject was color blind to about an eighty per cent saturation of reds and greens. The right eye was myopic and the left eye was hypermytropic. Both eyes were astigmatic at asymetric axes. After twenty years of these eye defects the subject's sight was corrected to 36-20. Before this correction and

notwithstanding these defects, various letters of the alphabet were colored. In such instances as involved red and green the subject either confused the two colors or identified them by their blue or yellow components. The author advanced the unusual view that colored hearing depended upon an insufficient balance of association or upon excessive powers of association along certain lines. Here the excessive associations were to be found between colors and sounds. These extreme associative tendencies were in turn dependent upon the fact that both the visual and the auditory excitations were linked up with the same tendencies toward motor expression. The motor expressions were made permanent by becoming associated with emotional processes. Back of it all as a condition under which these emotional processes arose, together with their motor accompaniments was a disturbance of the bilateral functioning of bodily physiological activities. Astigmatism, auditory defects, color blindness, speech defects and colored hearing were all dependent upon the proper balance or "cross-relation" in the bilateral functioning of the senses. A lack of balance conditioned these defects. When these forces, whose localization of function was bilateral were segregated or separated some unusual trait developed as a consequence. The tendency to form unusual associations was one of these consequences. In other words, colored hearing was the direct result of a lack of balance between the potential energy of the auditory and visual sense fields. The linking of auditory and visual excitations with a common but complex motor expression was also dependent upon this same lack of balance. Thus both stimulus and response were effected in like manner by the same cause. In summing up his theory, the author indicated that colored hearing represented an attempt on the part of the organism to adjust itself or to create a balance between segregated forces when such a balance was disturbed.

In 1907 Urbantschitsch (138) made another investigation of synaesthesia in which he found that the colors of sounds could be modified voluntarily by the subject and that external factors could also be made to modify the colors. In 1908 (139) the same author found that given a certain tone and its color equivalent, certain objective visual stimuli might be made to suppress the original association. This result could be obtained, however, only after the objective color was repeatedly presented to the subject at the same time as appeared the color equivalent of the sound.

In a similar fashion he was able to increase the strength of association between a color and a sound. In the same year Harris (56) described further instances of colored hearing in prose and poetry, the result of synaesthetic tendencies of the writers. This investigator criticised the current theories of colored hearing based upon the Hering and Helmholtz theories of vision. In these latter views it was held that the colors of tones followed the laws set forth in these theories of vision, i. e., if two tones aroused complementary colors, when the tones were given simultaneously, the result should be a grey. The author could find no evidence of this fusion in his own case.

In 1908 Laures (77) described a complicated form of synaesthesis in which "a" was associated with: (1) the color, green; (2) an insipid and unpleasant taste; (3) a sensation of coldness; (4) a tactual experience of touching a smooth surface like a pane of glass.

In 1909 Raines (114) found another peculiar form of synaesthesis. The subject had persistent color associations with tones, and certain drawings or figures such as a circle, triangle and swastika sign. Serrated lines were sea-green; the word "morning" was green; the symbol P.M. was red; evening was dark purple. The emotion of anger changed every red color equivalent to green. Odors, names of persons and names of many objects were likewise colored. Aside from these photisms, the subject possessed two complicated series of vivid imagery which tended to take possession of her consciousness whenever her mind was otherwise unoccupied. One of these sets consisted of vivid visual imagery of a green hill; the hill was surmounted by two broken marble columns; in the foreground of the picture was a blue sea. The second set consisted of a moorish gateway which led into a courtyard where the spray from a dashing fountain cooled the air. The atmosphere was perfumed with the fragrant odor of pomegranate flowers. Standing guard over this latter scene was a black giant clothed in garments of snowy white. This imagery could not be traced to any specific cause. It was present as far back as she could remember and had always been a source of great pleasure to the subject. This peculiar mental trait is consistent with the fact that the subject was a mystic and a spiritualist. She had premonitory dreams; she had acted once or twice as a medium and she had performed feats in automatic writing. One

would be led to suspect that her persistent imagery was, perhaps, a hyterical phenomenon.

In 1909 Rose (118) published the results of a brief statistical study among two hundred fifty-four subjects all of whom were women. She found that nine per cent of them had color associations. In the same year Martin (92) attempted to discover if synaesthesis facilitated one's appreciation of art. Her method consisted chiefly in presenting copies of paintings to her subjects and her data was received from prospective and critical reports. The author claimed to have found certain instances of "aesthetic synaesthesia."

In 1907 and in 1910 Ferrari (43) reported several cases of synaesthesia. One of his subjects revealed such idiosyncrasies of taste and smell as a preference of bitter for sweet and a fondness for disagreeable odors; and in this same subject tastes and odors were colored. In 1910 Mercanté (97) published a summary of an investigation among children and adolescents. He found eighty per cent of young girls to possess some form of synaesthesia but a somewhat lesser number among the boys. He concluded that synaesthesis was not only normal but the usual thing in children between the ages of eight and eighteen. Since there was a striking uniformity in those colors which were associated with vowels the author suggested that there might be a certain affective response to vowels and a similar affective response to the colors, that would explain this situation. Also in 1910 Lemaitre (83) published a statistical study of synaesthesis among adolescents. He found that only twenty-five per cent of his subjects had secondary sensations, half of which number, he believed, would lose their photisms after reaching maturity. It is interesting to note that Lemaitre found "i" to be associated frequently with white and "o" with black, a condition quite the contrary of the results found by Calkins and Jordan. Although Lemaitre was dealing with the French language and the latter investigators were dealing with the English language, "i" and "o" look quite the same in either language. This would indicate that their method of explaining these associations was faulty.

In 1913 Coriat (29) found colored pain in an abnormal subject who was afflicted with many ailments, hysterical hemerania, neurasthenia, somnambulism, transitory paralysis of the legs and right hemihyposthesia. Her field of vision was normal for form and for color. Hollow pain was blue; sore pains were red; head-

aches were vivid scarlet; and shooting neuralgia pains were white. The colors were exceedingly vivid and persistent when the pains were severe and prolonged. As the pains increased in their intensity the corresponding colors increased in brightness. This condition the author attributed to a process of summation. When the patient became hyperaesthetic on one side, a Von Frey hair aesthesiometer produced long-enduring pain after-images which latter were always highly colored. Both the pain and the color varied inversely as the length of the hair. Binet reported a similar case (12) in which tactual stimulations secretly administered by a needle prick failed to arouse a sensation of pain but gave rise to brilliant flashes of light. The patient was henianaesthetic and the stimulations were applied in the insensitive regions. In another patient and under the same conditions, Binet found that the tactual stimulations aroused black or very dark colors instead of brilliant flashes of light.

In 1911 Medeiros and Albuquerque (93) supported the association view of the origin of synaesthesis. They contended that secondary sensations were much more common than most investigations indicated, and that the peculiar use of certain letters in different languages might lead to the formation of color equivalents. The idea was suggested to them by the fact that in the Portuguese language "u" is associated with black. Here "u" is the accented vowel in many words which signify black or dark objects. The usual difficulty of applying such a rule to all instances of synaesthesia is encountered here as well as in all other attempts to explain synaesthesis on the basis of association. In the same year, Ziehen (145) suggested that certain varieties of synaesthesia might be explained by the principle of irradiation in the same way as is explained the pains which shoot over the face when one is suffering with the toothache. On the other hand certain other varieties of synaesthesia could be explained only by having recourse to principles of association.

In the same year also, Downy (33, 34) reported a case of colored gustation in a subject who had defective taste. The color associations were very vivid and persistent, lasting at times as long as ten minutes after the tongue had been stimulated. The colors were unusually vivid when the subject was ill. Here, as in Pierce's subject, taste qualities were intimately fused with pressure qualities and the latter often determined the associated color. The subject salted or sweetened her food in order to change the "feel"

and not the quality of the taste sensation itself. Many of this subject's associations could be traced to the act of connecting the colors of objects with their tastes for often the photism corresponded exactly with the natural color of the food. The subject's limen for bitter sensations was abnormally high but for the other three taste qualities the limens were nearly normal. When weak or indistinct taste qualities were confused the colors were correspondingly fleeting and vague. The colors of tastes could be intensified by stimulating the subject with smells simultaneously with tastes. The more intense was the stimulation of the tongue, or the greater the area covered on the tongue, the more brilliant and lasting were the photisms. Odors failed to modify the quality of the taste-colors but rendered them more easily stimulated when weak solutions were applied to the tongue. As a rule sweet tastes were black; bitter tastes were red; salty tastes were some form of grey and sour tastes were varied shades and tints of green. If the liquid stimulus was cooled it had the result either of making the photism more brilliant or of arousing the complement of the photims. If the stimulus evoked an indistinct color, the color was made more distinct by adding salt to the solution. Sour solutions modified the color of bitter stimuli and neutralized the color of sweet stimuli. At times bitter and sweet stimuli, applied simultaneously, neutralized the colors. After-images from visual stimuli did not influence the colors of the tastes in any way. Certain tactual sensations, alone, gave photisms but in none of these latter instances were the colors so vivid as for tastes. Downey (35) made a study of the alleged literary value of synaesthetic expressions in poetry. Thirty-four fragments of verse from Poe, Shelly, Keats and Blake were presented to six observers with the instructions to select from the total number fifty short passages which seemed to possess the most literary value and to arrange these passages in order of their affectiveness. The verses involved descriptions of light in terms of sound, sound in terms of light as well as ordinary passages of description. Downey concluded, (1) that there could be detected in poetry no certain indication that the authors had synaesthesia; (2) that if a poet, with synaesthetic tendencies, made use of synaesthetic descriptions, his poetry would be incomprehensible to the general reader; (3) that the thirty-four fragments of verse which were selected for the experiment might have represented poetic ideosyncrasies on the part of the authors rather than synaesthetic tendencies.

In 1912 Marinesco (91) described the synaesthesis of a Roumanian woman who had an endless number of color equivalents for various sounds, including spoken words, and for written words. In this paper were included several colored plates representing the subject's photisms. Colored letters sometimes appeared on backgrounds of a slightly different hue or brightness, and the backgrounds varied irregularly in size and outline. Sometimes the backgrounds tended to assume the general form of the letter. In this paper, also, is to be found a rare bibliography.

In 1913 Bleuler (15) devoted an article to a criticism of the association theory, a paper which was evidently inspired by a particular desire on the author's part to refute the arguments of Pfister (108) who had written in favor of the association view the year before. Bleuler accepted a physiological theory for the following reasons: (1) dark or dull colors are associated with low tones, bright colors are associated with high tones; (2) the size and shape of the colors vary in the same direction as the pitch of the tones; (3) consonants are generally paler than vowels; (4) variations in the primary sensation uniformly produce variations in the secondary sensations; (5) colors are associated with other sensations so early in childhood as to precede the development of meaning or recognition. For instance a color may be associated with a certain letter or sound before the child knows the meaning of the stimulus or before he is able to recognize it and call it by name. Associations, alone, would reveal no such uniformities as have just been mentioned. Moreover, the colors of sounds are not "optical," not visual perceptions or ideas, for they possess qualities which are different from either visual sensations or visual ideas. Among these differences are their localizations in time and their subjective and objective reference. In other words photisms of colored hearing are not "seen" but are "heard;" the photisms of tactual sensations are not "seen" but are "felt."

In 1913 Wehofer (143) presented the general subject of synaesthesis with a description of his own and other cases. He reviewed the arguments for and against the association and physiological theories and offered the suggestion that the efforts of investigators be directed toward correlating the facts of colored hearing with the facts and theories of audition rather than with the facts and theories of vision. The writer himself was a musician and a student of Berlioz. He often attended recitals and musical festivals with a friend who likewise had colored hearing. Together

they studied the behavior of their photisms while they listened to the music. Wehofer found that in his own case affective processes greatly influenced the quality of the photisms and the readiness with which the colors were evoked.

In 1913 Coriat (30) described a case of synaesthesia in a hysterical patient. Colors were associated with sounds and with words; the days of the week had different "heights;" the seasons of the year had different "shapes" or "forms;" tastes were colored and affective processes were also colored. In this subject the color associations were irreversable, a fact which the author believed pointed to a physiological theory. An attempt was made to discover the origin of the synaesthesis by means of the free association method and hypnotism, but in this attempt only negative results were obtained. The absence of after-images when the subject held the photisms in consciousness for relatively long periods of time indicated that the synaesthesis was purely cortical. Coriat resorted to Sherrington's view of irradiation and suggested that there might be in the cortical projection fields an irradiation of specific sense energy into adjacent projection fields. There might also be an incomplete differentiation of function in these adjacent fields so that an excitation which reached one area, say the auditory, would arouse a molecular disturbance in an adjacent area, say the visual. In this way visual secondary sensations would result. This condition in the cortex might be congenital which would explain the early origin of synaesthesis in the life of the individual.

In 1901 and again in 1914 Lemaitre (81, 84) described some very remarkable cases of personification. He found that about three per cent of adolescents between the ages of twelve and fifteen showed a tendency to endow letters, numerals, or certain words with human traits. One subject experienced considerable difficulty in solving arithmetical problems because of the fact that the digits with which he was working gave rise to vivid and persistent dramatizations. The numeral 8 was a husband whose wife was 4; 3 was a son, twelve years of age; 6 was a timid and feeble daughter; 9 was a wealthy individual, a good friend of 8 but a special friend of 4; 7 was a woman of high social rank and a friend of 8; 5 was a charming lad, very unpretending, who held a unique relationship with each of the members of the family; 1 and 2 were insignificant individuals. The wife, 4, disdained her husbands affections and sought the friendship of 9. When-

ever the subject attempted to solve a problem in arithmetic there appeared these personified numerals in human form and outline, standing in a row in the order named above, and in the center of an immense circle. The circular plot of ground was surrounded by a grassy plain. Out on the plain was the habitual residence of the wife, 4, who never left her house except to go in search for her son, 3. At one side of the circle was a steep incline which lead upward in one direction to a stone embankment and downward in the opposite direction to a deep crevass. Then there appeared 4, with her son 3, near this wall. When they approached the wall the numerals combined to make 12. 5 and 3 then appeared on top of the embankment; they were seen to shake hands, whereupon the numbers combined to make 15. At the moment when the numbers combined, the human forms disappeared. Beyond the wall on a level terrace above was situated a stone enclosure where dwelt the numeral 5. After 5 had combined to make three, it reappeared and went into this stone enclosure. 7 then appeared on the brink of the precipice where 3 was seen to join him. 3 and 7 then combined to make 21. 4 was next seen chasing 7 in the direction of the chasm and when both numerals arrived at the chasm's edge they combined to make 28. In this fashion another drama was staged by 5, 6, 7, 8 and 9, in which, from time to time, different pairs of these numerals combined to make larger figures. Lemaitre thought that the subject formed the habit of dramatizing these numerals when he was very young and in the first stages of learning writing, language and vocabularies.

In 1914 Langfeld (75) described a case of synaesthesis which, like many others tended to point to a physiological theory. Here the colored hearing seemed to follow the laws of color mixture in that when two tones whose colors were complementary were sounded simultaneously there appeared an approximate grey. This result was best obtained when the original colors were blue and yellow. Musical chords assumed the color of the fundamental. The subject could see the color of a tone when the name of the tone was mentioned as well as when the tone itself was presented to her. In the sames year Myers (100) reported a form of colored hearing where the colors were determined conjointly by the intensity of the tone and by the pitch. This author believed that the color associations were neither sensory nor imaginal, but imageless and verbal. He suggested that the associations were

formed in childhood when primary perceptions were still vague and undifferentiated. Synaesthesis was the persistence of this vague and undifferentiated form of perception. Aside from this the subject probably showed a strong tendency to form synaesthetic associations between those sense fields in which there remained vestiges of the old, imperfect and undifferentiated sensory experiences. This view was attacked by Langfeld, Pierce and others. One of Myers' subjects was the Russian composer, Alexander Scriabine. The composer once tried to have his "Prometheus and Mystery" given with colored lights and odors in order that the visual, auditory, and olfactory sensations might blend into one great harmony and thus produce a greater effect upon the audience. Scriabine's colors were associated with the harmony of music and with musical tonality. Changes in the colors often preceded the change in tonality with which the colors were associated. This made it possible for the composer to judge harmonies by their colors. In 1916 (14) Blanchard seemed to have found a successful method of producing a sound-color harmony at a musical performance.

In 1917 (71) Jordan reported on the photisms of his son, on whom tests had been made between an interval of five years. Several minor changes had occurred in the color associations, all of which were evidently due, however, to inaccuracies in describing the colors.

In 1918 Alford (2) reported two cases of colored hearing in two male twins, twenty-seven years of age. Both subjects were very much alike in their mental traits. Both were brilliant students in all their studies; both could perform remarkable feats of learning; they liked and disliked the same things; both were fond of poetry, art, and architecture and both were temperamentally emotional, sympathetic, sensitive, shy and modest. On one of the subjects tests of the photisms were made three months apart. Unfortunately the experiment had to be abandoned very early in its course for the reason that the subjects became suspicious and failed to cooperate. 150 proper names were used as stimulus words and in a rather loose manner the subjects were asked to write the names of the colors which the stimulus words aroused. In certain instances the names evoked no color at all; in other instances they evoked several colors among which the dominating color was hard to determine. In most instances the colors were practically as vivid as the real sensations. It was found in this

investigation, contrary to Whipple's results, that under conditions of fatigue the colors were more readily stimulated. After the subject sat in an experiment for longer than half an hour there appeared a persisting and confused array of colors which always obscured the appropriate response. A possible indication of reversability of the associations was found in one of the subjects who could recall several proper names when the stimulus word was a certain color. The responses were the names which always aroused that particular color. Although the colors remained fairly constant over a period of three months, certain stimulus words aroused a color during the first tests and failed to arouse any color in the second test. Conversely certain words which failed to arouse colors in the first test did so in the second. One of the purposes of this investigation was to discover how nearly the associations of the two brothers resembled one another. It was found that the photisms were similar with 67 per cent of the test words. Harris and his brother had previously reported a similarity in their own cases of only 50 per cent (56). As the author suggested, the 67 per cent was probably too high and had the method been more refined and the descriptions of the colors more accurate, the similarities would have been less noticeable. Alford suggested that spectra and scotomata might be synaesthetic phenomena. Several indications in this study point to the associative origin of the synaesthesia: (1) the associations were frequently reversable; (2) certain words evoked colors at one time and not at another; (3) the name Brown was "brown." Sue was blue, Fern and Verne were green, Monday was blue (blue Monday) and the like.

SUMMARY OF HISTORICAL REVIEW

No thorough going study has been made of synaesthesis in the blind. Only seven of such cases have been described in the literature which the present writer has been able to obtain. There have appeared no characteristic differences between synaesthesia in the blind and in the seeing. The relationship of synaesthesis in the blind to the onset of blindness if there is any such relationship, has never been worked out. The only theory which has been offered to explain synaesthesis in the blind was offered by Phil-

lipe (109) who thought that such associations were due to an effort on the part of the subject to retain his memory for colors. If Phillipe's results are to be accepted as representative, synaesthesis would seem to be slightly more prevalent among the blind than among the seeing, suggesting that a certain number of such cases may follow from the fact that the subjects have lost their sight. In those cases of synaesthesis which have developed before the subject became blind no subsequent changes due to blindness have been noticed.

Frequency of Synaesthesis: The frequency of synaesthesis among adults has been found, under varying conditions of age and sex, to range from nine per cent to fifteen per cent. The frequency among adolescents has been found as high as twenty-five per cent. It seems probable then, that many cases of synaesthesis disappear when the subject reaches maturity.

The following is a list of the different varieties of synaesthesis which have been reported in the literature. They are arranged according to the apparent stimulus. It happens that the list indicates in a general way the order of their frequency, beginning with the first as the most common variety.

- I. Of acoustic origin
  - A. colored hearing
    - 1. isolated tones
    - 2. noises
    - 3. music
    - 4. chords
    - 5. vowels
    - 6. consonants
    - 7. words
      - a. names of people and other proper names
      - b. common parts of speech
      - c. days of the week
      - d. months of the year
      - e. seasons
      - f. epochs of history
      - g. virtues and other abstract terms
      - h. phases of human life
      - i. names of tastes
      - j. names of odors
    - 8. digits
    - 9. dates
  - B. gustatory audition
    - 1. taste equivalents for words
  - C. figured audition
    - 1. geometrical forms associated with words
  - D. pain-audition
    - 1. toothache equivalents for tones of certain quality

II. Of visual origin
- A. colored lines
  - 1. serrated lines
  - 2. broken lines
- B. Colored forms and figures
  - 1. geometrical forms, square, circle, rectangle, triangle etc.
  - 2. colored angles, obtuse, acute
  - 3. colored signs and designs, swastika etc.
  - 4. colored multiplication, division, addition, subtraction signs
- C. colored letters, digits, words etc.

III. Of gustatory origin
- A. colored tastes
- B. colored taste and pressure complexes
- C. colored taste and odor complexes

IV. Of olfactory origin
- A. colored odors

V. Of tactual origin
- A. colored pain
- B. colored pressure
- C. colored temperature sensations
  - 1. warm
  - 2. cold
  - 3. mixtures
- D. auditory pain
- E. auditory temperature sensations
- F. cutaneous or muscular taste (see page 5).

VI. Of affective origin
- A. colored pleasantness and unpleasantness
- B. colored emotional complexes

VII. Of possible combined visual and auditory origin
- A. personification and dramatization of letters, digits, days of the week. (It is more likely, however, that associations play a very important role in the origin of this form of synaesthesia.)

Localization of secondary sensations in synaesthesis. Colors for sounds are usually localized in the direction of the sound but in a few instances such colors have been localized on the brain or against the forehead. The color equivalents for letters, digits and words are frequently localized in space in front of the individual, or as backgrounds upon which the letters or words are visualized. In a few instances of this latter sort, the letters themselves are colored. The photisms of taste have usually been localized in space in front of the subject. Taste equivalents for sound have always been localized in the mouth of the subject. In brief, the secondary sensations have been localized almost invariably as if they were the primary sensation no matter to what actual primary sensation they have been attached. This would indicate that in most forms of synaesthesia the secondary sensations depend upon a sufficient differentiation of function in the sensory centers to warrant a consideration of the laws of that sense field from which the secondary sensations are derived.

Methods of attack upon the problem. (1) By means of standard laboratory apparatus efforts have been made to survey, exhaustively, the varieties of colored hearing in different individuals in view of discovering the extent of the phenomenon, its constancy and the factors which influence its intensity, quality, duration and clearness. (2) Attempts have been made to add to our knowledge of the problem by the use of hypnotism, the free association method and by resorting to recall of the subject's earliest memories. (3) Investigators have tried to find the appropriate stimulus for the secondary sensations by resorting to modifications in stimuli, to the use of distractions or counter stimuli or by reversing the order of the association, if possible. (4) Another method has consisted of the application of weak farradic currents to different portions of the cortex. (5) Attempts have been made to correlate synaesthesis of different forms with ideational types and with temperamental or emotional types. (6) The reaction method has been used in order to find the association time between colors and their associates. (7) Statistics from questionnaire methods have been used in order to discover uniformities of various sorts among different individuals having synaesthesis. (8) Attempts have been made to ascertain the modifiability of secondary sensations under voluntary effort and practice or in the presence of continued distractions. (9) Data have been collected from large numbers of individual cases in view of explaining the origin of synaesthesis, the manner in which it develops and the degree of persistence of the phenomenon. (10) Attempts have been made to correlate the functioning of visual secondary sensations with the laws of color mixture and the functioning of olfactory and gustatory secondary sensations with the laws of smell and taste.

Generalizations from experimental data. Experimental evidence warrants only a few generalizations concerning synaethesis. Uniformities which seem to possess the least number of exceptions are: first, synaesthesia may be permanent as far as tests show; secondly, in colored hearing, tones of high pitch are associated with bright or light colors and tones of low pitch are associated with dull or dark colors; thirdly, an increase in the intensity of the primary sensation is accompanied by a corresponding increase in the intensity or brightness of the secondary sensation; fourthly, synaesthetic associations are not, as a rule, reversible; fifthly, the areas in the brain involved in synaesthesis are adjacent to one another; sixthly, synaesthesis begins in early childhood. The follow-

ing negative conclusions are perhaps the most striking in the literature: (1) there is no uniformity, among different individuals, in the hues which are associated with tones of like quality or pitch; in the colors which are associated with the same vowels, letters, words, consonants and diphthongs or with the same tastes, odors, pressures, etc. (2) Various experimental methods have failed to throw light upon the problem of ultimate nature of synaesthesis or upon its origin. Among these are the reaction method, hypnotism, the free association method, weak farradic stimulation of the brain, correlating the associated colors with the laws of color mixture, observing the effects of distracting or counter stimuli, and attempts to voluntarily inhibit the secondary sensations. On the other hand, the debatable problems are: (1) synaethesis is either inherited or it is not inherited; (2) fatigue diminishes the intensity or brightness of the secondary sensations or has the reverse effect; (3) synaesthesis may best be explained on physiological grounds or it may best be explained by means of the principles of association.

Factors Determining the Nature and Attributes of the Secondary Sensations. The hue of color equivalents for sound is generally determined by the quality of the tone. The brightness of the color is determined by the pitch and intensity of the sound. The hue, in other instances may be determined either by an emotional accompaniment of the sound sensation or by fortuitous associations. The color equivalents for chords are determined either by a component tone whose color is striking, by the fundamental tone, or by mixing the colors of the component tones. Colors for music are determined either by the key in which the music is written or by the composer's name. The colors for vowels may be determined by the shape of the letter, by the sound of its pronunciation, by affective concomitants, or by peculiar methods of usage of the vowel. The colors for consonants may be determined by the same factors as in the case of vowels, or by the position of the consonant in certain words. Color equivalents for words are determined by the color of accented vowels or consonants, by the colors of letters which are repeated in the word, by the colors of initial letters, by a mixture of the colors of component letters, by affective accompaniments, by the color of a component letter the hue of which is unusually striking, by associating the word with the natural color of the object for which the word stands etc. The colors for tastes and smells are often determined, apparently,

by the natural color of the objects tasted and smelled. On the other hand words for tastes may be colored according to the color of the odor which is commonly associated with such a taste. The colors for digits may depend upon the numerical value of the digit. The colors for dates or large figures may be determined by component digits, by the class of the numeral, or by the number of syllables in the name of the figure. Other conditions which may influence the quality or intensity of secondary sensations are fatigue, emotional experiences and mode of stimulation. Fatigue generally reduces the intensity, clearness and hue of the secondary sensation or lessens its liability of appearance; on the other hand, one investigator found it to have almost the opposite effect (see page 3). Emotional processes may intensify the secondary sensation or alter its quality, entirely. The mode of stimulation may increase its liability to appear, it may increase its clearness or intensity, or it may alter its quality. In the case of colored hearing differences have been noted in the photisms when each ear has been stimulated separately. The use of counter stimuli has been known to alter the nature of the photisms in colored hearing. In rare instances voluntary efforts to modify or to inhibit secondary sensations have evidently been successful. In rare instances, also, such factors as color-blindness, a condition of hyperaesthesia, and defects in the sense organs have been known to determine the nature and quality of the secondary sensations. More of such determinants of the attributes of secondary sensations might be cited but their lack of verification and uniformity among different individuals makes it hardly worth the while. In fact many of the factors just mentioned have been noted only in isolated cases and it is perhaps questionable whether the reports are always accurate.

Theories of the Origin of Synaesthesis. Four different classes of theories have been advanced from time to time in the literature: the pathological, physiological, association or psychological and a combined physiological and psychological theory. The early attempts of Cornaz (31) and Marcé (89) to attribute colored hearing to an eye defect have been discredited. We have, therefore, the three remaining views. The first noteworthy physiological interpretation was advanced by Nuel (102) and since that time there have been made many supplementations, suggestions of omissions or corrections by different writers. The theory in gen-

eral includes the important fact that functionally, and perhaps anatomically, there is a close relation between those reflex arcs and brain areas which give rise to the primary and secondary sensations. The functional relation may be one of irradiation, of interaction, of reciprocal innervation, or of a lack of differentiation of function. It may be that the anatomical relationship is one of anastomosis of afferent fibers or of adjacent areas in the brain. In the light of recent theories of irradiation and summation in reflex arcs, the anatomical condition of anastomosis or of tangling of fibers seems to have lost its importance. At any rate such discoveries have had the result of producing a change in the emphasis from structural to functional factors in a theory of synaesthesis. The most plausible explanations, perhaps, rely upon an irradiation of impulses from their usual center to adjacent centers of the brain. In the projection areas of the latter there is thought to be such a lack of differentiation of function as would give rise to secondary sensations. This lack of functional differentiation might account for the simultaneity in the appearance of the secondary sensation with the primary sensation. It would also account for the dependence of the former upon the latter in intensity, clearness, quality and duration. As Epstein suggested, afferent impulses may be deterred into other channels at the corpora quadrigemina or in other basal ganglia. There may be in the appropriate areas of the brain a certain blood distribution, resulting from shock, emotional experiences or some unknown physiological cause. This distribution might affect the functioning of the areas concerned and no others. In this way energy in the form of heat might be so distributed between these two areas as to stimulate them into simultaneous functioning, thus facilitating irradiation or increasing the results of a lack in differentiation of function. The unique view advanced by Evans (see page 22), although seemingly impossible in its present form, may be modified, eventually to the advantage of a general physiological theory. It takes into account certain physiological principles which other theories omit and which may prove to be highly important, for example, the balance in bilateral functioning of the body and the linking up of synaesthesis not only with conditions of stimulation but also with conditions of response or motor expression. It seems plausible that synaesthesis may depend quite as well upon the functioning of entire reflex arcs as well as upon functions localized specifically in the brain centers. Some forms of

synaesthesia may have an origin similar to that of the conditioned reflex.

The following facts support a physiological view: (1) the almost simultaneous presence of secondary with primary sensations at the point of origin; (2) the close proximity of brain areas involved in synaesthesis; (3) the stimulating influence of drugs; (4) the irreversibility of synaesthesis; (5) the destructive influence of fatigue or the reverse effect; (6) the disappearance of synaesthesis in adolescence or in senescence; (7) the dependence of attributes of secondary sensations upon the properties of the stimulus of the primary sensation; (8) the appearance of synaesthesis in early childhood at a time when meaningful associations are not yet formed; (9) the spontaneity and suddenness with which synaesthesis begins.

The first important psychological explanation of synaesthesis was given by Perroud (107). In general this type of theory may rely upon the alleged fortuitous and simultaneous experiencing of sensations from two different sense fields or upon the habit of constantly visualizing objects in their natural colors. Again, an experience in one sense field may become associated with an experience in another sense field for the reason that both experiences have a common affective concomitant. It may be, also, that colors are deliberately associated with tones, letters and the like, in certain instances, in order that the subject's memory may be improved. In the main, each individual case of synaesthesis must be interpreted differently, if one is to rely upon an association theory. The details of individual cases differ widely as well as the conditions under which each case originates. There are undoubtedly certain forms of synaesthesis which are the outcome of associations. The weakness of an association theory, however, in accounting for the general phenomenon is its inadequacy in covering a majority of all cases, even of the same type. Moreover, the association view, in a last analysis, must rely upon a physiological explanation. The few instances in which the association view seems adequate are: (1) cases which date from some unusual event or experience; (2) photisms which correspond to the colors of the object originally sensed; (3) photisms whose colors are suggested by the position of a letter in a word which designates a certain colored object.

It is clear that such differences of opinion as have existed from time to time between investigators of this problem have been

the result first, of generalizations from too few cases; secondly, they have been the result of the vast differences exhibited between different varieties of synaesthesia, and of the great complexity of the phenomenon and thirdly to the fact that both physiological and association views have seemed adequate to meet the demands of individual cases while neither view has apparently met the demands of all cases. In such cases as colored odors and tastes, in which the photisms correspond to the natural colors of the objects tasted or smelled, for example, it would be the natural thing on first thought to resort to an association theory, but after all, a physiological view would probably in these instances provide a better explanation than to rely upon the traditional process of association for association is not a cause, as the writer sees it, but a physiological condition. Furthermore, to be understood, association must be described in such terms as irradiation or draining of physiological processes. In a last analysis, therefore, the final appeal must be made to a physiological theory.

THE SYNAESTHESIS OF A BLIND SUBJECT

The subject whose synaesthesia is described in this section of the paper is Thomas D. Cutsforth, a graduate of the University of Oregon. He lost his sight by accident at the age of eleven and at the present writing he is twenty-seven years of age. He has had an extensive laboratory training in psychology and is a good introspector. His general scholarship was exceptional and his work in psychology was uniformly excellent. He is at present engaged in teaching, and in the near future he plans to continue his studies in psychology by taking graduate work.

The following is a list of his various forms of synaesthesia and allied phenomena:

1. colored tones; colored auditory imagery of these tones and photisms for the names of these tones
2. colored music; colored auditory imagery of music; photisms for names pertaining to music
3. colored vowels and consonants, covering the entire alphabet
4. colored voices; similar colors for the name of the person whose voice is colored; similar colors for visual imagery of these persons and for verbal imagery of the persons' names
5. colored proper names, cities, towns, states, countries, places etc
6. colored cutaneous experiences; photisms of kinaesthetic experiences, touch and kinaesthetic blends
7. colors for abstract terms, theories, beliefs
8. colored tastes and odors; photisms for the names of tastes and odors, which often correspond with the colors for the tastes and odors themselves; colors for auditory or verbal imagery of these names
9. colors for names of the days of the week, months of the year

10. colored digits, dates, telephone numbers etc., and for auditory and verbal imagery of the same
11. colors for the directions—south, north, east and west; similar colors for auditory and verbal imagery of the words
12. colors for affective experiences and certain emotional complexes
13. photisms in dreams, associated with imagery in other modalities and with visual imagery itself
14. colored number forms, week, month, century and alphabet forms

A series of experiments was made during the winter of 1916-17 and in the summer of 1919 in view of determining the constancy of these colored associations. The tests were made on February 9, March 9, June 9, 1917, and on August 15, 1919. Preliminary tests revealed the following facts which enabled us to simplify the method:

1. The subject experienced some difficulty in properly labeling the different colors. Therefore we resorted to the method of asking him to select certain known objects whose natural colors, as he remembered them, resembled the color of the photism he was attempting to describe. Accordingly, many of the colors are described in the text as as a beeswax yellow, the yellow of newly sawed boards, fawn color, cherry red etc. Some allowance must be made, therefore, for slight variations in terminology, in comparing the photisms for the same stimulus over long periods of time. In repeated tests, however, the subject was able to choose his comparisons with remarkable accuracy.

2. It was found that the colors for imagery of tones, voices, tastes etc. were identical with the colors for the actual primary sensations themselves. The subject was able in this way to arouse the color of a certain tone by getting an auditory image of the tone and the same way with taste. Moreover, in most instances the same colors were aroused when the experimenter named a person as were aroused when the subject heard that person speak. Certain of the tests were given, therefore, with the names of tones, persons, tastes and the like as stimulus words. The accuracy of the results was checked in two ways, by resorting from time to time to the primary sensation as the stimulus and by resorting to complete introspections from the time the stimulus word was given to the time the appropriate color appeared. In cases of unfamiliar tones or objects, as for example certain touch blends and organ tones, actual objective stimuli were employed.

3. The subject has a habit of translating the voices of other people into verbal imagery of his own voice. This peculiar ten-

dency appears very conspicuously in his dreams where conversations between persons in the dream appear in the reagent's own voice. This imagery is accompanied by the colors appropriate to the person's voice in question, and is identified by color instead of by quality of voice. By resorting to verbal imagery as a stimulus, as well as the name of the person and the person's voice itself, it was very often possible to check the accuracy of the results.

Colors appear for voices of all persons whom the subject has heard speak, whether in conversation, or a lecture; singer's voices are also colored. These colors appear the first time the voice is heard and are projected in the direction of the sound. They appear as small clouds or "fog-banks", sometimes spoken of by the subject as "blankets". Usually the photisms are more vivid and persistent when the stimulus is the voice itself. After periods of several months or years during which time the reagent has not heard a particular voice, the colors begin to fade, usually turning into some shade or variety of brightness before disappearance altogether. On the other hand the colors are apt to remain longer than any memory of the person's name. As soon as the reagent becomes familiar with a person, auditory and verbal imagery of that person's voice readily excite the appropriate color. The brightness and the hue of such photisms oftentimes resemble one another to a marked degree, yet there is always some distinguishing feature about each photism which enables the subject to identify it easily. He is able to compare these relatively similar colors with striking readiness. For example the color of C's voice is very much like M's but lighter, or J's is like O's with the exception of a few black specks in it etc. It has been impossible to explain the reasons why particular hues or brightnesses become attached to particular voices except in rare instances where the photism seems to result from associations. For example Ha's voice is "pink" because the voice lacks character and "pink" is a faint and characterless color for the reagent. Occasionally the brightness of the voice is determined by the affective tone which accompanies the subject's perception of the voice. Congenial voices are apt to be bright or silvery grey. Disagreeable voices are often very dark or almost black. But there are many exceptions to these rules. A peculiar complication enters into the subject's photisms in connection with voices. Not only does the person's name arouse the color of the voice, but the name itself often possesses a color of its own, determined in part by the com-

ponent letters. For example W's name arouses the silver grey photism of W's voice and also a relatively pure white photism which is associated with the name, alone, as a word.

The colors for persons occasionally undergo slight changes both in hue and brightness as time elapses from the last hearing of the person's voice or as the reagent's emotional attitude toward the person changes. The brightness of a photism sometimes becomes more marked as the relationship between the reagent and the person in question becomes more congenial. If the relationship changes from a pleasant to an unpleasant one the photism is apt to become darker. At the present writing introspective reports show that both like and dislike for a person produce a light halo or overcast about the photism and that the quality of the person's voice, analyzed more thoroughly as the reagent becomes acquainted with it, governs the coloring of the photism. One example illustrates the change which a photism undergoes under these conditions of familiarity and change in attitude. A certain person's voice was originally a very dark and richly saturated brown. On further acquaintance, dislike for him changed to congenial friendship and with this change the photism became brighter and developed a "shiny gloss such as observed on the surface of polished woodwork." The richness of the brown did not change perceptibly.

The following are typical examples of photisms for voices. The left-hand column contains the initials standing for the person whose voice is colored. The descriptions are taken verbatim from the reagent's introspections. On March 9, 1917, and June 9, 1917, the stimulus was either the person's voice or the name of the person given to the reagent shortly after hearing the person's voice. On August 15, 1919, the reagent reported his colors from auditory imagery of the person's voice or from associations aroused by the person's names. In considering this latter series of tests, it should be borne in mind that unless specified in the tables, the reagent had not heard the actual voice for several months and in certain instances not for two years:

	March 9, 1917	June 9, 1917	August 15, 1919
Wh.	silver grey	whitish silver on dark grey background	dark grey with bright silver gloss
Con.	greyish yellow, old straw-color	brownish yellow, color of a ripe English walnut	yellowish grey, poorly saturated, like old beeswax

	March 9, 1917	June 9, 1917	August 15, 1919
Sch.	dark bluish black, very muddy, black predominating	dark muddy color, slight greenish tinge	"smudgy" grey, very dark; dusty overcast, tinged with yellowish brown; "negro" color
DeC.	reddish brown	reddish brown, slightly yellowish	a greyish red-brown, poorly saturated
Cam.	bright canary yellow	canary yellow	a very bright yellow, golden or canary
Hag.	chocolate brown, very dark	chocolate brown	dark, rich reddish brown, chocolate in appearance
Hay.	dark grey; light streaks running through it	light grey, darker at times, fluctuating in brightness	a rich dark silver grey
Reb.	dark reddish brown, also blue tinge	very dark brown; bluish tinge	dark mahogany; reddish brown; fringe of poorly saturated brown
Zah.	orange	orange, yellowish	a washed out orange bordering on a poorly saturated yellowish brown
Sha.	maroon	glossy red, maroon color	poorly saturated red; a sort of faded maroon

The following are voices which the reagent has heard repeatedly during the progress of the experiment:

Fat.	steel grey	shiny steel grey	dark dusty grey poorly saturated
Mot.	bluish grey, dove color	smoky grey, bluish tinge	mouse color, not very bright, faded appearance
Sis.	yellow; beeswax	mixture of yellow and pale orange, like new rope	well saturated yellow but rather dark
Bro.	the black of a faded umbrella	dark dusty brownish black	smudgy black, almost a faded dark grey

The following are colors for voices which the reagent has not heard for periods of three to five years; the photisms are associated with auditory imagery of their voices:

Tof.	black	greenish black, very dark	deep black
Ros.	brown, reddish tinge	brown	dark reddish brown
Cha.	bluish green with yellow overcast	greyish green, dusky	dark bottle-green
Wes.	a very light dove-grey	dove grey	silver grey with slight tinge of yellow
Hor.	bright yellow	yellow	very light yellow, bordering on light yellow-tan

High tones arouse small photisms of a faint hue and light tint, merging into light greys as they become higher. Low tones give large, dark photisms, with rarely much hue. Intermediate tones give photisms which are moderately bright and moderately saturated. The size and brightness of the photisms for tones vary also with the intensity of the sound. Loud tones produce colors of lighter tints but do not otherwise alter the hue. Combinations of tones result in a superposition of colors and very rarely in what could be called a mixture. There is never a true neutralization of complementary colors. If actual sounds are used as stimuli, the colors remain in consciousness as long as the reagent attends to the auditory perception. If an auditory image is the stimulus, the photism is unsteady and fluctuates in clearness between a maximum which undoubtedly corresponds closely to the clearness of a visual perception, to a minimum clearness, characteristic of a vague and fleeting visual image.

When several tones are sounded in a chord, or when the reagent is listening to music, colors come and go with kaleidoscopic rapidity. The individual notes seem to retain their own hues and degrees of brightness, but as a background for the changing colors, there appears, for piano music, a changing blankets of blues and greens. For band music this ''blanket'' is more yellowish.

The following are examples of photisms for tones. As before, the stimuli for the different tests are the same:

	February 9, 1917	August 15, 1919
piano, high tones	brilliant white	a very bright white
medium tones	bluish grey	grey
low tones	dark grey	almost black
Galton whistle	minute sparks of silver colored light	streaks of brilliant ''brightness'' with no color
flute	different shades of blue bordering on violet	faded out blue, higher notes have no color but merely degrees of brightness; not so bright as piano
cornet	beeswax yellow, very bright	yellow; golden color; higher notes almost white; lower notes very pale and darker
full organ	very rich deep black, bluish cast, spots and streaks of brown, with flames of brilliant light irradiating from all sides	very deep chestnut brown, approaching a black, dark bluish or greenish caste

The form and outline of colors for sounds vary greatly from a mere thread-like line or streak to a shapeless "cloud" or "blotch." Sustained tones arouse "extended and thread-like" photisms which become longer as the tone is sustained. Short, quick notes, like staccato notes on the piano, arouse small, short streaks of color, depending upon the length of time the tones are sustained and upon the rapidity with which they follow one another. Large, continuous sounds, as for example a factory whistle, arouse widely expanded areas of color, resembling the side of a hedge or other uniform and solid colored mass. If the whistle is broken up into successive blasts, the "hedge-like" photism is likewise broken up into sections. The organ and cornet photisms are shaped like dominoes or similar bar-like objects. These bars always appear in a vertical position. The violin photisms are similarly bar-shaped but appear slanting upward and to the left. Other instruments produce photisms in a horizontal position. Photisms are not stationary in the visual field. As the reagent's attention shifts from the sound stimulus, for example, the photisms become fainter and travel upward, ultimately merging into a grey background.

The photisms for taste and smell are the most difficult of all for the reagent to describe. This is probably due to several reasons. First, the photism seems to be associated now with the taste of an object and now with its odor. Photisms are becoming confused with retained visual memories or visual associations with the actual objects themselves. When the name of a taste is given as the stimulus there may appear one color which will soon give way to another color of an entirely different hue, as the reagent becomes aware of gustatory or olfactory imagery of the object for which the name stands. The following photisms were reported in a series of tests in which the reagent was asked to recall gustatory and olfactory imagery as the stimuli for the photisms:

	March 9, 1917	August 15, 1919
sour	light grey	muddy grey splotch with upper half quite light, lower half much darker
sweet	yellowish green, very light	pale white, very light
salt	reddish brown, the color of fresh iron-rust	white with several specks and streaks of black running through
bitter	yellowish brown, a little browner than beeswax	yellow, brownish tinge

vinegar	dark green	poorly saturated greenish yellow
quinine	yellow	dark golden yellow
onions	pale buff yellow; the color of manila paper; changed to light blue with olfactory imagery becoming clearer	bright silvery white with occasional streaks of blue
cheese	bright yellowish brown	reddish grey
strawberries	very dark red	rich bluish red, redder than purple
ginger	mahogany red	poorly saturated brown with minute bright specks of white light
ripe peaches	creamy white	light, amber yellow superimposed on a poorly saturated green
pineapple	very dark red	very dark maroon or blackish-red

Introspective reports, similar to the following, indicate that the reagent's color associations for tastes and smells are being confused with possible remnants of visual imagery of the objects themselves. Numerous examples could be given which indicate that the color of the photism has been determined by the color of the object itself. "I perceived the words 'Green prune' and was immediately aware of a small cloud of silvery white light, appearing in front of me and about four feet from my face. I was on the point of reporting 'silvery-white' when I became conscious that this was an old visual remembrance of the inside of a green Italian prune. For some little time I then endeavored to get imagery of the taste of green prunes. When the imagery came the photism changed to a dark blue, almost black with silvery-white streaks running through it. This I recognized as the color of the taste." The colors for many tastes and odors seem hopelessly mixed with visual associations of the objects themselves. Voluntary efforts to visualize fruits and flowers often result in the arousal of colors which oftentimes resemble the photisms for their tastes or odors. It is probable that the colors associated with tastes and smells are influenced, also, by tactual factors.

The colored associates for cutaneous sensations have undergone considerable change during the period of experimentation. Much of this, however, is probably due to finer analysis later in the experiment. The photisms for cutaneous and kinaesthetic pain are often so vivid as to dominate consciousness to the temporary

exclusion of any awareness of the pain itself. The colors for cold, hot and pressure are readily obtained by stimulation of any part of the body. The intensity of cutaneous sensations always determines the saturation of the color and the degree of brightness. The coldness of ice-water, whether drunk or applied to the body gives rise to an exceedingly saturated blue, ranging to black. Hot water, at almost a burning temperature gives rise to photisms of "inky black." Hot liquids are disagreeable to drink for the reason that the reagent imagines himself drinking "ink."

	March 9, 1917	August 15, 1919
hot	dark blue, ranging to black	a dark, dirty grey, ranging to black
cold	black	very black, dead, without gloss
pressure	yellow and yellowish brown	yellowish grey, varying degrees of yellow according to intensity of the stimulus
pain	flashes of brilliant light	black

Cutaneous and kinaesthetic blends arouse changing photisms as the blends themselves change. For example when the subject is drying himself after a bath, the body, while wet, is a dark greyish tan which becomes whiter as the drying process continues. Wet tactual impressions are tan or some other shade of brown. A wet portion of the towel, for instance, is darker and browner than the drier portions.

When the reagent attempts to locate places, visually, on the map, they always appear in the same color as is aroused when he hears the name of the place spoken or when he thinks of the place in terms of auditory-vocal-motor imagery of his own voice. When names of places are mentioned orally, to the reagent, the first color to appear is that of the person's voice; when his attention shifts to the name of the place, proper, the photism changes. In the associations of colors with places, there again may be observed the influence of early experiences in the life of the subject. As far back as the reagent can remember, he formed the habit of learning the names of states and their locations on the map by associating them with the colors as they appeared on the map. Evidence of this fact can be found in the subject's tendency to locate places on a map, in colors, whenever the name of the place appears in his consciousness and again in the circumstance that certain states, distributed widely throughout the United States, appear in the same colors. An attempt was made

to obtain the geography from which the reagent first studied that subject but a copy of it is not available. This point, therefore, cannot be verified.

The stimulus in each instance for the following reports was the name of the place in question:

	March 9, 1917	August 15, 1919
Oregon	greenish blue, yellow over-cast	light yellowish green poorly saturated
Washington	dark bluish green	dark bluish green
California	reddish orange	pale reddish yellow
Texas	very dark drab color	a dirty drab, the color of fir tree trunks
Arizona	color of buck-skin	a bright straw yellow with a tinge of light brown
Utah	dove-grey	dove color with possible light yellowish tinge
Idaho	dove color but lighter than Utah	light smoky blue; faint
Montana	mahogany red	mahogany red, slightly more red than polished mahogany wood
North and South Dakota	light yellow, tinged with a drab-grey	a beeswax yellow
Wyoming	beeswax yellow	faded orange, red almost gone, mostly a tan yellow
Colorado	dove-grey, darker than Utah	dove-grey, dark, almost a slate blue
Kansas	dark tan, like Arizona although somewhat darker	copper shade, dark yellow or reddish tan
Missouri	very dark red, almost black	very dark brown, almost black
Georgia	very light grey, almost white	almost white, background of grey, dominating color is white
Kentucky	blue, very dark	dark bluish black
Ohio	yellow	buff yellow, almost a bright yellow
Virginia	light green	greyish blue-green
Maryland	blue	navy-blue
Rhode Island	white	color of dirty white house
Chile	red	light reddish brown, dominating color, brown
Switzerland	bluish black	a dead bluish black
France	a red mahogany	very rich brownish red

	March 9, 1917	August 15, 1919
Alaska	greenish black as a basic color, bright yellow spots	bright yellow with dark spots
Argentina	tomato red	light tan, streaked and spotted with pink
Ireland	bright yellow	bright yellow, approaching an orange

Color associates for letters and digits are aroused by hearing the name of the letter or digit pronounced, by reading it aloud, or by obtaining tactual impressions in American Braille. The forms of certain of these photisms resemble in shape a figure made by connecting the points of the corresponding braille letters; others have vague resemblances of the printed letters. As time progresses, however, most all of these photisms tend to approach the size and shape of a small square. They are localized from eighteen inches to about two feet from the reagent's face, which suggests the early influence of visualizing reading material.

The following reports were obtained with the names of the letters or digits as stimuli. Tests with American Braille give practically the same results.

	March 9, 1917	August 15, 1919
a	creamy yellow	yellow of rather high degree of saturation, between orange and lemon
b	jet black	very rich and dark bluish black sometimes slightly glossy, almost the black of crow feathers
c	dark silvery grey	light dusty color, too light for smoke or dove color but more like dust on new rubber goods
d	bluish grey	color of bottle-green
e	dull white	a brightness, just light
f	reddish brown	dull brown, poorly saturated, like a faded brown house
g	glossy white	white, or slightly greenish white
h	a foggy, greenish grey	dark, dirty grey, like weather-beaten boards
i	very brilliant white	white, brighter than "g" but not as bright as "e"
j	creamy yellow, different in shape from "a"	the light yellowish grey of boards, turning old
k	brownish-orange	copper-yellow, carrot-color
m	moderately saturated blue	brown, with yellow tinge, old fallen leaves
n	very light blue, lighter than "l" and "m"	same as "m" but lighter and less saturated
l	faded blue	smoky blue, rather pale

	March 9, 1917	August 15, 1919
o	dark muddy color	smutty black, like an old dingy stove
p	pale bluish green	light greenish-blue, washed out in appearance, something like the color of blue-flag
q	dead, smoky black	very dark greenish black
r	black, like "b," but different in shape	the black of a black felt hat
s	light yellow	either a very light yellow or creamy white, color of oil-lamp flame
t	very dark brown	a light chocolate brown
u	tan yellow	greyish yellow, poorly saturated
v	very pale blue	smoky blue, poorly saturated, very light
w	slate grey, larger than "q" and not as dark as "b" and "r"	smudgy, smutty black, like poorly blackened shoes
x	dark brown, two shades	rich black with fringe of red
y	reddish blue, almost violet	color of faded black ink
z	very dark purple	very dark, almost black, tinge of red, not as red as "x"

The colors for digits are similarly fixed over long periods of time. Numbers in the tens class are more richly colored than those in the units class. The photisms for the hundreds class are very poorly saturated. Colors for the thousands class appear on a dark grey background; those for the millions class appear on a bright yellow background. Complex numbers of several digits possess the colors of the component digits and the colors are superimposed upon a background which corresponds to the class indicated by the number of digits. For example, 85 has two colors, the yellowish grey for the 8 and the bluish black for the 5; the colors appear in bars, side by side. 851 has three colors, 8531 has four, and so on.

As a rule, the letters whose sounds are louder, more brilliant, or resonant, are brighter and lighter than the others. The explosive letters, such as b, g, k, p, t, have the greater saturation.

The following are the reagent's reports of his photisms for directions of the compass. The stimuli were the names of the directions. The same colors appear when the reagent is conscious of attending to the same compass directions, whether or not verbal imagery is present in his consciousness.

	March 9, 1917	August 15, 1919
north	black	very rich black, or bluish black
south	yellow	sand-colored yellow
east	red	a reddish brown, bordering on reddish orange
west	brown	little bottle greenish-brown

Foreign words which have become anglosized and English words derived from foreign roots are recognized, by the subject, from their colors. The following are illustrations:

	March 9, 1917	August 15, 1919
German words	dark buff	dark brown, very dark
French words	reddish brown	rich but light brown
Latin words	very dark blue	dark bluish black, the blue very rich
Greek words	white, with faint tinge of blue	a smoky, silvery brightness, bordering on bright grey, almost white

automobile—light blue, chauffeur—reddish brown, conduct—'con' dark blue with 'duct' a shade of brown, pantheist—light steel blue.

The following are color associates which have originated since the subject entered college. The stimuli were the names for different theories or abstract terms, standing for different lines of thought.

	March 9, 1917	August 15, 1919
"Great man" theory in history	very dark brown	dark yellowish grey
"Economic interrelation" theory in history	pale green	poorly saturated and light green
"geographic" theory in history	dark green	very dark bluish green
Weissman theory	dark, glossy, rich reddish brown	strongly saturated reddish brown
behaviorism	drab color	a slaty, bluish black
geneticism	white	a very light, dusty, slightly greenish white

The following are *O*'s reports of colors which are associated with affective and emotional experiences. Tests indicated that the colors which were aroused by associating the name of the experience with the experience itself were as faithful as the colors which appear in the actual presence of the emotion.

	March 9, 1917	August 15, 1919
pleasantness	yellow	light yellow
unpleasantness	blue-grey	dull, dark grey
anger	very intense bluish black ranging to "jet" black	black when there is no muscular movement; action arouses light streaks which run through the black
joy	silvery-grey, ranging to white, according to intensity	yellowish-grey; silver cast

Tones, voices, tastes and odors have been colored as far back as *O* can remember—to approximately five years of age. Digits first became colored when he began to study arithmetic, at the age of seven. It was at this period, also, that number forms originated. Letters, however, were not colored until the subject began to study the point alphabet at the age of eleven, just after becoming blind. Places, such as states and countries, were first colored, as far as the reagent can remember, when he began to study geography in the intermediate grades at school. He derived much help from these colored associates before and after blindness set in. Photisms for systems of abstract thought, theories etc., did not appear until the subject entered college. Each type of color association developed spontaneously, but after its appearance, was voluntarily practiced for the assistance it gave the subject in learning and in reasoning.

Interesting light upon the behavior of these photisms may be found by a reference to the genetic stages of the process of recognizing. When a new sound, whether a person's voice or a nonsense syllable is first heard, a color immediately appears, determined in part by the pitch of the sound, an affective component, if any, or the resemblance of the sound to a familiar one which already has a color. An interesting illustration of this immediate appearance of the color is to be found in the fact that the names of towns, areas, localities etc. in the war zones aroused vivid colors on hearing them for the first time. A second hearing of the same name never failed to evoke the appropriate color. As soon as the subject becomes so familiar with a new name or voice as to be able to get an auditory or verbal image of it, this imagery is appropriately colored. The appearance of the color is a large factor in bringing familiarity with the recalled experience. Subsequently, in the process of forgetting, the vocal-motor or auditory imagery is the first factor to disappear, leaving a feeling of familiarity with its

component motor attitude, together with the colored "blanket." For example, after the name of a certain French village in the war territory had been forgotten there was still left the appropriate color for the name of the village. The hue of the color, and the shape and size of the photism then meant to the subject that particular French village. Still later, in the process of forgetting, all associations such as remembrances of events that had taken place in this particular French village disappeared, leaving, in the reagent's recall, only the colored "blanket" which was aroused by the general situation, "village in France" as the stimulus. The same procedure, in forgetting, is characteristic of other subject matter, such as history, geography, or what not. Still later, in the process of forgetting, the photism itself may become fainter, less saturated, until none of its attributes can be recalled. Many times colors appear in the reagent's consciousness which have lost their original associates and can be identified only as the color for a "certain person's voice," a "certain place" whose identity has been forgotten. Thus, in the process of learning and forgetting the objective stimulus appears at the outset with its color. The color is ultimately the last detail of the experience to disappear from the reagent's memory.

The case thus reported presents several peculiar characteristics which have not hitherto been discussed at length in the literature nor have they been subjected to prolonged and intensive laboratory tests. Color associations similar to those of waking life appeared in the dreams of one of the Nussbaumer brothers (103). Our reagent reports similar phenomena. Galton (49) noted that in certain instances number forms had permanent colors as well as numbers. Our reagent has colored number forms in which the numbers are not visualized but are represented by colors or by different shades of brightness. Calkins (20, 21), Hennig (59), Flournoy (46), Lemaitre (81, 84), Grüber (55), Pedrono (106), Mendoza (95) and others have noted that color associations are not confined to the field of perception alone but are also found in the field of imagery. Tendencies to dramatize or to "personify" letters, words, numbers and the like may be included in this category as well as photisms or other synaesthetic phenomena in thinking and in dreams. In the case of our observer not only are auditory, tactual and other sensory experiences associated with colors but images of these experiences are associated with identically the same colors. Moreover, the names for different tones, the

names of persons whose voices are colored and the names of other sensory experiences suffice, in most instances, to arouse the same colors as do the actual sensory experiences themselves. In both instances of imagery and of names only one sensory experience is required before the color is likewise associated, apparently permanently, with the corresponding image or name. It seems probable, therefore, that the same physiological condition which would explain synaesthesia in the field of perception might also apply in the field of imagery.

Since synaesthetic phenomena in the field of imagery to all appearances reveal the same characteristics as do the same phenomena in the field of perception, to regard synaesthesia as belonging to the latter field alone is probably an error. Not all investigators of this problem have reported the fact that the associated image appears in processes of imagining, thinking, etc. A sufficient number of positive cases have been reported, however, to lead one to believe that if all cases had been thoroughly analyzed the same synaesthetic phenomena would have been found in the field of imagery as well as in the field of perception. Several other considerations point to the conclusion that synaesthesis is not a phenomenon of perception alone. First, the color or other associated image may outlive the primary experience in the process of forgetting. Secondly, the photism or associated image may appear in connection with a subliminal stimulus in the absence of the primary sensation. Thirdly, under conditions of fatigue, nervous excitement or of drug taking, the behavior of the secondary image is altered to a greater extent than the behavior of the primary experience. Fourthly, the secondary image shows further, a greater degree of independence of the primary experience than most investigators have apparently assumed, in that when colors for two tones are complementary, these colors tend to follow the first law of color mixture. One investigator (55) found that the photisms tended to follow the second law of color mixture.

A theory of synaesthesis based on laws of reflex action would undoubtedly explain in better fashion the facts of synaesthesis than any theory which confines its interpretations to structural conditions of afferent pathways, to arterial conditions, or to such a general condition as a lack in differentiation of function between adjacent brain areas. We are inclined to the view, therefore, that synaesthesis is a peculiar form of reflex action which, for the sake of a better term, we shall designate as an immediate and

permanent "conditioned" reflex. The test of the theory lies in further evidence obtained from experimentation. The view certainly has the advantage of being more flexible than other theories. It is more specific. It accounts better for the fact that one particular color and not another becomes associated with a certain stimulus. Whereas the conditioned reflex as we have come to regard it requires more than one repetition of the stimulus before it is formed, it might be argued that there is no dividing line between various conditioned reflexes which require a shorter or a longer time in becoming established and that in synaesthesis we have an example of a conditioned reflex which is established on the first appearance of the stimulus, instead of on the second, tenth, or fiftieth repetition of the stimulus. We anticipate the objection that conditioned reflexes have an end effect—the secretion of a gland or the contraction of a muscle—and that synaesthesis reveals no such end effect, in answer to which we can only reply that for the sake of clear thinking, this view of synaesthesis assumes that mental processes are responses—forms of implicit behavior—which can be described in terms of laws similar to those laws by which we describe overt behavior. In synaesthesis, the end effect would be the associated image.

But we have speculated too much already. We must know more facts. The phenomenon of synaesthesis presents an exceedingly rich field for further experimentation. It should be studied genetically, with emphasis upon the behavior of the phenomenon. We have gone into the history of the problem in some detail in order to make this paper the first of a series of articles bearing upon experiments on Mr. Cutsforth.

An intensive study of synaesthesis should prove fruitful of many practical results both for general and applied psychology.

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Note. From time to time there have appeared discussions of synaesthesia in the popular literature. Because such articles contain so little of scientific interest or worth they have not been here reviewed. We mentioned in the text of this paper that attempts had been made to associate colors with music during a musical performance, by means of a color organ. On March 20, 1915, in New York, the Russian Symphony Orchestra presented Scriabine's ''Prometheus,'' with colors. A few years previous to this A. Wallace Rimington experimented with a color organ, in London. Accounts of the color organs, and the success or failure of the experiments from the standpoint of art are discussed in certain of the following popular articles:

Binet, A. Problem of colored hearing. *Chaut.* Vol. 16, 1892-1893, O. S. 447-450.
Butler, L. S. Color in singing. *Musician*, Vol. 14, 1909, 313.
Copp, Laura R. Colored hearing. *Musician*, Vol. 19, 1914, 517.
Current Opinion, Vol. 57, 1914, 181-183, Physiologist's analysis of the mind that thinks in colors.
Current Opinion, Vol. 58, 1915, 332-333, Color Music—Scriabine's attempt to compose a rainbow symphony.
de Parkville, Henri. Association of colors with sounds. *Popular Science Monthly*, Vol. 23, 1883, 490-492.
Downey, June E. Seeing sounds and hearing colors. *Independent*, Vol. 73, 1912, 315-318.
Doyle, Edward R. Will color music become an art? *Bookman*, Vol. 41, 399-401, 1915.
Durham, F. Color Music, a British Columbian Study. *Canadian Magazine*, Vol. 12, p.49.
Evans, Edwin. Life and musical work of Scriabine. *Fortnightly Rev.*, Vol. 103, 1915, 1071-1080.

Gaskell, Ellen S. Color pitch of music. *Westminster Rev.*, Vol. 169, 1908, 559-564.

Harris, D. F. Colored thinking. *Canadian Magazine*, Vol. 47, 1916, 213-217.

Literary Digest, Vol. 46, 1913, 1378-1379.

Literary Digest, Vol. 51, 1915, 17.

Luckiesh, M. Art of mobile color. *Scientific American Supplement*, Vol. 79, 1915, 408-409.

Person, Charles W. Seeing music in colors. *Illustrated World*, Vol. 24, 1915, 44-45.

Plummer, H. C. New art created with the aid of science. The color organ used in Scriabine's Symphony, ''Prometheus.'' *Scientific American*, Vol. 112, 343, 1915.

Review of Reviews, Vol. 51, 1915, 747-749.

Rimington, A. Wallace. Color Music, London, Stokes.

Runciman, John L. Noises, smells and colors. *Musical Quarterly*, Vol. 1, 1915, 149-161.

Spaulding, W. R. Inter-relationship of the ear and the eye. *Etude*, Vol. 38, January, 1920, 11-12.

Sullivan, John W. H. Organ on which color compositions are played; new art of color music and its mechanism. *Scientific American*, Vol. 110, 1914, p.163.

of the brain but in certain instances some of these excitations might be deflected at the corpora quadrigemina where the proximity of visual and auditory ganglia is very close. From here the auditory excitations might pass over visual paths to the visual area of the brain.

A valuable discussion of synaesthesis was published by Hennig in 1896. In this paper (59) he classified secondary sensations as physiological and as psychological, according to their origin. The first group depended upon peculiar nerve connections and the second depended upon the formation of peculiar associations. That certain forms of synaesthesis were undoubtedly psychological in origin was borne out by the striking example in which a certain subject associated clarinet tones with the color, blue. At one time this subject was listening to a clarinet solo, while standing out of doors. As he was looking upward toward the sky, he became absorbed in the tones from the instrument, momentarily noticing at the same time that the blue of the sky was unusually rich and clear. From that time on clarinet tones aroused this same shade of blue. Of chief interest to this author was the practical value of many forms of colored hearing and for that reason a considerable portion of the article was devoted to this phase of the topic. He observed that poor spellers, who were at the same time synaesthetic, were occasionally helped by the colors which always accompanied different letters. Painters and musicians had recourse at times to their color associations in painting and in composing. Mathematicians sometimes used their color associations to good advantage in solving mathematical problems. On the other hand he found so few instances in which the secondary sensations were a positive disadvantage that he believed them to be an agent of superior mental endowment. He took the attitude that the associations should be cultivated by all individuals.

In 1897 Flournoy (46) described an elaborate and striking case of "personification" in a young man of nineteen. Names of the days of the week were dramatized as follows: Monday and Tuesday were a sad young man who held a fore-finger over one eye. This figure designated dark weather. Wednesday was a young man in the act of stealing an object behind him, bending over and extending his arms backward, between his legs. This figure also indicated dark weather. Thursday was a man in the act of turning a knob in the kitchen door on his way to the room

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Tuesday were a sad young man who held a fore-finger over one eye. This figure designated dark weather. Wednesday was a young man in the act of stealing an object behind him, bending over and extending his arms backward, between his legs. This figure also indicated dark weather. Thursday was a man in the act of turning a knob in the kitchen door on his way to the room